and walking at night until being dehydrated by 10 percent of body weight. If soldiers rest at all times and wait for help, they can increase their survival time (assuming death when dehydrated by 20 percent of body weight). Survival times (without water) in desert climates with average daily temperatures (dry bulb) of 80°, 90°, 100°, and 110° F are ~7 days, ~4 days, 3 days, and 2 days, respectively. For comparison, in a 60° F climate soldiers could survive ~16 days without water.

Table 3-5. Distances that soldiers can march in the desert (at night) with different amounts of water before being limited by dehydration exhaustion

Daytime Average Temperature (° F)*	Number of miles, with different water supplies			
	0 qt	1 qt	4 qt	10 qt
80	45	50	70	110
90	20	25	35	50
100	15	18	20	30
110	9	10	15	20

*Daytime average dry bulb temperature was about 15° F below maximal temperature.

3-7. Electrolyte (salt) replacement

a. In addition to water, sodium, chloride and other electrolytes (potassium, calcium, and magnesium) are lost in sweat. Sweat sodium concentration can range from 10 to 70 millimoles per liter (mmol/L) depending on diet, sweating rate, and heat acclimatization status. Heat acclimatization conserves sodium by decreasing sweat salt (NaCl) content by ~50 percent (for example, sweat sodium decreases from 50 to 25 mmol/L for the average soldier).

b. Figure 3-6 provides the daily sodium requirements for heat-acclimated soldiers (assuming sweat sodium concentration of 25 mmol/L) over a range of daily energy expenditures (activity levels) and daily mean WBGT index levels (2.5 grams NaCl contains 1 gram sodium). Daily sodium requirements range (for sedentary to very active persons) from ~2 to 4 grams (5 to 10 grams NaCl) per day in cool climates and up to ~5 to 11 grams (12 to 28 grams NaCl) per day in very hot climates. Most soldiers working and living in hot weather will have daily sodium requirements of 4 to 9 grams per day (10 to 23 grams NaCl).

c. Daily sodium consumption for garrison dining ranges from 2.3 to 9.5 grams (6 to 24 grams NaCl; 95 percent confidence limits) and varies because of food preferences. Each meals ready to eat (MRE) contains an average of 3.6 grams of sodium (2.0 grams in food and 1.6 grams in salt packet). If three MRE are consumed, then soldiers will have a maximum of 10.8 grams of sodium (27 grams NaCl), but only 6.0 grams of sodium (15 grams NaCl) if the salt packets are not eaten. Therefore, soldiers should consume their entire MRE ration and salt packets during periods of strenuous physical work in the heat.

d. If soldiers are heat acclimatized and fully consume their meals (MRE, including salt packets), sodium intake will be adequate except for the most extreme hot weather conditions. Increases or decreases in body sodium stores are usually corrected intuitively by adjustments in appetite. Physical activity increases hunger, and the associated increased food consumption usually covers the additional sodium required. If soldiers perceive they need additional sodium, such as the first several days of hot weather, this can be achieved by salting food to taste. Salt tablets are not recommended as their misuse has resulted in gastrointestinal discomfort and incapacitating nausea.

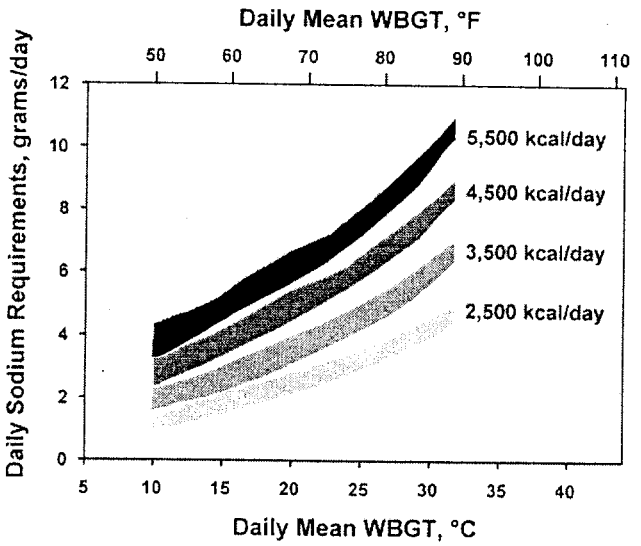

Figure 3-6. Daily sodium requirements during various daily climatic (WBGT) and metabolic (kcal/d) conditions

e. If meals are not consumed, salt supplementation should be employed during prolonged (>4 hours) periods of profuse sweating in hot weather. A method to replace salt losses, in approximate proportion to sweat losses, is to salt drinking water at a concentration of 0.1 percent (17 mmol/L sodium). Salt can accentuate the taste of chlorine, so the salt concentration may need to be diluted (to taste) in treated water. Mixing the following will produce salted drinking water: (See Appendix D.)

(1) One lb (0.45 kilograms) table salt to 100 gallons of water.

(2) One-fourth teaspoon table salt to each quart of water.

f. Sports drinks are an effective source for electrolyte replacement during prolonged (>4 hours) periods of profuse sweating in hot weather. Sports drinks should meet the following criteria: sodium ~15 to ~30 mmol/L, potassium ~2 to ~5 mmol/L, and carbohydrate ~5 to ~10 percent. The type of carbohydrate (for example, glucose, sucrose, or polymers) does not matter (although high fructose should be avoided as it may cause gastrointestinal side effects). The carbohydrate in sports drinks makes them an appropriate rehydration beverage for other situations, such as—

(1) Before initiating strenuous exercise if meals are not consumed for >4 hours.

(2) During prolonged (>6 hours) exercise if meals are not consumed.

(3) For therapy for heat-related disorders.

g. The primary concerns with sports drinks are their caloric density. If soldiers drink 5 qt (~4 calories per gram carbohydrate and 8 percent solution) of sports drinks that would constitute about 1,600 kcal. Therefore, sports drinks should be used during conditions described above and not to totally replace water consumption.

h. Canteens containing carbohydrate (sugar) solutions increase the growth of harmful bacteria, increasing the incidence of gastrointestinal upset. If sugar-containing beverages are carried in the canteen, then additional sanitation efforts are needed. Canteens containing carbohydrate solutions should be rinsed with water daily and treated with hypochlorite solution every two or three days. The frequency of these sanitation actions depends on the quality of water, liquid temperature, and composition of the beverage. Flavoring reduces the effectiveness of chlorine to fight microbial growth, so these beverages should be added to already purified water and consumed within several hours.

i. Commercially flavored electrolyte powders with no calories are available (for example, Oral Rehydration Salts and Gator LYTES®), and electrolyte/carbohydrate powdered (for example, Powerade®

and Gatorade®) products are available. These products can be dissolved and diluted to taste in canteens (containing purified water). Gator LYTES® and Gatorade® are registered trademarks of PepsiCo, Inc., 700 Anderson Hill Road, Purchase, NY 10577. Powerade® is a registered trademark of The Coca-Cola Company, P.O. Box 1734, Atlanta, GA 30301.

3-8. Special military situations

a. U.S. Navy heat stress problems aboard ship often involve high heat and humidity (greater than 90° F dry bulb temperature or 81° F wet bulb temperature) conditions. Physiological Heat Exposure Limit (PHEL) guidelines have been developed for these situations and published in Navy Medical Department Publication (NAVMED P)-5010-3. The PHELs are the maximum allowable conditions of work and WBGT index levels. The PHEL guidelines are to be used for short-term work exposure of up to eight hours. The limits presume that no prior heat injury is present and that no cumulative fatigue exists prior to exposure.

b. Aviation heat stress problems involve maintenance crews and flight crews who are exposed to heat stress. Flight crews encounter heat stress during preflight, engine start, taxiing out, and standing by for takeoff. Total ground time can be considerable even in fighter aircraft. Additionally, the heat load experienced in the cockpit is more severe than on the ramp because of the reduced air velocity, personal equipment worn and increased radiant heat load. The WBGT index in the cockpit may be as much as 20° F (11° C) higher.

c. Flight crews of high-performance aircraft require effective protection from heat and dehydration in order to maintain both physiological resistance to inflight stress and ability to operate a complex weapons system under dynamic conditions. Specifically, aerial combat entails sequences of aerobatic maneuvers with levels of acceleration (G-stress), which challenge human tolerance limits; both heat stress and dehydration will lower the threshold at which the crew may lose consciousness. Although fighter crews experience only limited physical workloads in the cockpit, flight clothing imposes a significant thermal burden for hot weather operations. The multilayered, protective clothing includes cotton underwear, fire-retardant coveralls, antigravity suits, parachute harness, boots, gloves, and helmet. A chemical defense layer may be added as underwear or incorporated into the coverall. The process of dressing in this ensemble, walking to the aircraft, and conducting preflight inspection on a hot ramp significantly raises core temperature. Thus, it is an already warm crew that enters the cockpit of a heat-soaked aircraft and goes through the sequences required for engine start.

d. Modern fighter aircraft often has cockpit cooling during ground operations (standby and taxi); however, the thick clothing and impermeable layers of the antigravity suit mean that the occupants receive only limited benefit. Typically, heat removal occurs so slowly that the aircraft is in combat or returning to base before cooling is complete. In wartime, crews are expected to fly two, three, or more missions in quick succession with little chance to achieve full recovery in terms of body temperature and hydration.

e. The Fighter Index Thermal Stress (FITS) provides a measure of heat stress expected by aircrew in jet aircraft with canopies (see Air Force Pamphlet 48-151) and is calculated as follows:

$$^{\circ}\,\mathbf{F} = 0.83\ T_{wb} + 0.35\ T_{db} + 5.08$$

The following FITS procedures are designed to minimize heat stress impact assuming (as described in Table 3-6):

(1) FITS caution zone (dry bulb temperature from 100° F to 110° F).

(a) Encourage crews to drink water before cockpit entry, during standby, and in flight.

(b) Be alert to symptoms of heat stress.

(c) Avoid exercise 4 hours before take-off.

(d) Precool cockpits by means of air-conditioning the ground carts.

(e) Assign alternate crewmembers to perform preflight aircraft inspection.

(f) Keep the sun out of transparencies by using rolling roofs or fabric covers.

(g) Transport crewmembers directly to the aircraft.

(h) Limit the permitted duration of in-cockpit standby.

(2) FITS danger zone (dry bulb temperature 115° F to 120° F), plus caution zone recommendations.

(a) Keep the sun out of transparencies by using rolling roofs or fabric covers.

(b) Allow only one change of aircraft before requiring return to ready room in cases of mechanical delay.

(c) Optimize conditions for cooling and rehydration between flights.

(d) Support self-assessment and empower crews to stand down when they judge that further flights would be unsafe.

Table 3-6. FITS reference values

Dry Bulb Temperature	Zone	Dew Point Temperature								
(F)		30	40	50	60	70	80	90	100	>110
70		70	73	76	81	86	X	X	X	X
75		74	77	80	84	89	X	X	X	X
80	NORMAL	77	80	83	87	92	98	X	X	X
85		81	83	86	90	95	101	X	X	X
90		84	87	90	93	98	104	110	X	X
95		88	90	93	96	101	108	112	X	X
100		91	93	96	99	104	109	115	122	X
105	CAUTION	94	96	99	102	107	112	118	124	X
110		97	99	102	105	109	114	120	126	133
115		100	102	105	109	112	117	123	129	136
120	DANGER	104	105	108	111	115	120	125	131	138